Table 9 Effective Desensitization by Pinpoint forward link DSSS and video Devices

	Phone indoor	Phone outdoor	Cylink	Cellnet meter	Cellnet base	Video outdoor	Video indoor
Pt=	57	57	57	57	57	57	57 dBm
hu=	200	200	200	200	200	200	200 feet
hw=	4	4	25	6	25	25	6 feet
BWu=	8	8	8	8	8	8	8 MHz
BWw=	2	2	5.2	2.5	2.5	5	5 MHz
f=	10	0	0	0	0	0	10 dB
Psens	-100	-100	-95	-105	-105	-90	-90 dBm
SNR	15	15	15	15	15	20	20 dB
d=	**10.02**	**17.83**	**42.43**	**30.78**	**62.83**	**42.02**	**11.58 miles**
Range r	7	7	7	7	7	7	7 miles
No. in Range	6	20	115	61	253	113	9
Ft=	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Pb=	0.06	0.19	0.69	0.46	0.92	0.68	0.08
Pbmax=	**0.06**	**0.19**	**0.30**	**0.30**	**0.30**	**0.30**	**0.08**

Table 10 Effective Desensitization by Pinpoint forward link to FH devices

	Phone indoor	Phone outdoor	Metricom typical	Metricom peak	Metricom Concentrator	Itron base
Pt=	57	57	57	57	57	57 dBm
hu=	200	200	200	200	200	200 feet
hw=	4	4	25	25	100	6 feet
BWu=	8	8	8	8	8	8 MHz
BWw=	0.2	0.2	0.16	0.16	0.16	0.2 MHz
f=	10	0	0	0	0	0 dB
Psens	-100	-100	-100	-100	-100	-115 dBm
SNR	15	15	15	15	15	10 dB
d=	**5.64**	**10.02**	**23.70**	**23.70**	**47.40**	**21.83 miles**
Range r	7	7	7	7	7	7 miles
No. in Range	2	6	36	36	144	31
Ft=	0.01	0.01	0.01	0.01	0.01	0.01
Pb=	0.01	0.02	0.11	0.11	0.36	0.09
Pbmax=	**0.01**	**0.02**	**0.11**	**0.11**	**0.30**	**0.09**

Table 9A **Near Far Ratio ref Pinpoint forward link DSSS and video Devices**

	Phone indoor	Phone outdoor	Cylink	Cellnet meter	Cellnet base	Video outdoor	Video indoor
Ptw=	27	27	30	30	23	0	0 dBm
Ptu=	57	57	57	57	57	57	57 dBm
hw=	4	4	30	25	25	25	6 feet
hu=	200	200	200	200	200	200	200 feet
BWu=	8	8	8	8	8	8	8 MHz
BWw=	2	2	5.2	2.5	2.5	5	5 MHz
SNR	15	15	15	6	15	20	20
f=	10	0	0	0	0	0	10 dB
NFR(eff)=	**0.01**	**0.01**	**0.03**	**0.04**	**0.02**	**0.00**	**0.00**
dw=	0.01	0.02	1.00	0.05	0.05	0.10	0.01 miles
du=	**0.75**	**2.67**	**32.26**	**1.26**	**3.18**	**26.77**	**3.07** miles
Range r	7	7	7	7	7	7	7 miles
No in range	0	0	67	0	1	46	1 bases
% in range	**3.61**	**45.61**	**100.00**	**10.25**	**64.65**	**100.00**	**60.52** %
Ft=	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Pb=%	**1.00**	**1.00**	**48.87**	**1.00**	**1.00**	**36.97**	**1.00** %

Note: When "No. in range" = 0, Pb is for those devices at risk.

Table 10A **Near Far Ratio ref Pinpoint forward link FH devices**

	Phone indoor	Phone outdoor	Metricom typical	Metricom peak	Metricom Concent.	Itron meter
Ptw=	27	27	32	32	32	-6 dBm
Ptu=	57	57	57	57	57	57 dBm
hw=	4	4	25	25	100	6 feet
hu=	200	200	200	200	200	200 feet
BWu=	8	8	8	8	8	8 MHz
BWw=	0.2	0.2	0.16	0.16	0.16	0.2 MHz
SNR=	15	15	25	25	25	10 dB
f=	10	0	0	0	0	0 dB
NFR(eff)=	**0.01**	**0.00**	**0.01**	**0.01**	**0.01**	**0.00**
dw=	0.01	0.02	0.125	0.125	4	0.01 miles
du=	**1.33**	**4.74**	**16.72**	**16.72**	**267.50**	**9.70** miles
Range r	7	7	7	7	7	7 miles
No in range	0	1	17	17	4587	6
% at risk	**11.40**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00** %
Ft=	0.01	0.01	0.01	0.01	0.01	0.01
Pb=%	**0.31**	**0.31**	**5.10**	**5.10**	**100.00**	**1.83** %

Note: When "No. in range" = 0, Pb is for those devices at risk.

3. Desensitization by Metricom 'Ricochet' on Part 15 Devices

Tables 11 and 12 show the calculated probability of blocking by the Metricom base stations on Part 15 devices. These tables are given in order to establish the degree of interference that Part 15 devices must be overcoming already in order to co-exist. The point being that the interference avoidance techniques that must have been implemented could possibly be applied to avoiding interference to LMS in the few cases where it occurs.

If the distance between transmission sites is r, then the number of interfering sites that are in range of the device is :

$$\text{No. in range, } Nb = \pi\, D_d^2/r^2$$

For DS devices, the Metricom transmissions hop over the entire 26 MHz band, thus the proportion of transmission within the band of the device is $BWw/26$.

The transmit duty factor for each base station is Ft, hence the proportion of time the device is not blocked is therefore $(1 - Ft.BWw/26)$. For Nb transmissions, the probability of being not blocked is $(1 - Ft.BWw/26)^{Nb}$, and hence the probability of being blocked, Pb, is:

$$Pb = 1 - (1 - Ft.BWu/26)^{Nb}$$

In the case of frequency hopping devices, from equation (11) in Annex A, the probability of blocking is:

$$Pb = 1 - (1 - 1/M)^{Nb.Ft}$$

where M is the number of hopping channels.

Tables 11 and 12. Tables 11A and 12A show the practical, or typical, amount of blocking that should be experienced when the typical operating distances are considered.

Table 11A shows that:

- the Cylink and outdoor video systems will be totally blocked.
- about 10% of indoor DS phones, and all outdoor DS phones, will experience 3% blocking
- all indoor video devices will experience 19% blocking.

Table 12A shows that the blocking to other FH devices is very small.

These results do not represent the actual blocking because they do not take into account any of the interference avoidance procedures of the devices. The results merely indicate the degree of potential blocking that needs to be overcome. It must be noted, however, that this interference cannot be avoided by selecting other channels. The Metricom system transmits across the entire band and thus will effect all other devices.

Table 11	**Effective Desensitization by Metricom bases DSSS and video Devices**						
	Phone indoor	Phone outdoor	Cylink	Cellnet meter	Cellnet base	Video outdoor	Video indoor
Pt=	32	32	32	32	32	32	32 dBm
hu=	25	25	25	25	25	25	25 feet
hw=	4	4	25	6	25	25	6 feet
BWu=	0.16	0.16	0.16	0.16	0.16	0.16	0.16 MHz
BWw=	2	2	5.2	2.5	2.5	5	5 MHz
f=	10	0	0	0	0	0	10 dB
Psens	-100	-100	-95	-105	-105	-90	-90 dBm
SNR	15	15	15	15	15	20	20 dB
d=	**1.19**	**2.11**	**3.96**	**3.45**	**7.05**	**3.96**	**1.09 miles**
Range r	0.25	0.25	0.25	0.25	0.25	0.25	0.25 miles
No in range	71	225	789	599	2495	789	60 bases
% int hops	7.72	7.72	20.06	9.65	9.65	19.29	19.29 %
Ft=	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Pb=	**0.89**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**0.99**

Table 12	**Effective Desensitization by Metricom bases on FH devices**		
	Phone indoor	Phone outdoor	Itron base
Pt=	32	32	32 dBm
hu=	25	25	25 feet
hw=	4	4	6 feet
BWu=	0.16	0.16	0.16 MHz
BWw=	0.2	0.2	0.2 MHz
f=	10	0	0 dB
Psens	-100	-100	-115 dBm
SNR	15	15	10 dB
d=	**1.19**	**2.11**	**4.60 miles**
Range r	0.25	0.25	0.25 miles
No in range	71	224	1065 pps
Ft=	0.4	0.4	0.4
Pb=	**0.16**	**0.43**	**0.93**

Table 11A	**Near Far Ratio ref Metricom bases DSSS and video Devices**						
	Phone indoor	Phone outdoor	Cylink	Cellnet meter	Cellnet base	Video outdoor	Video indoor
Ptw=	27	27	30	30	23	0	0 dBm
Ptu=	32	32	32	32	32	32	32 dBm
hw=	4	4	30	25	25	25	6 feet
hu=	25	25	25	25	25	25	25 feet
BWu=	0.16	0.16	0.16	0.16	0.16	0.16	0.16 MHz
BWw=	2	2	5.2	2.5	2.5	5	5 MHz
SNR	15	15	15	6	15	20	20
f=	10	0	0	0	0	0	10 dB
NFR(eff)=	**0.22**	**0.13**	**0.41**	**0.63**	**0.25**	**0.05**	**0.04**
dw=	0.01	0.02	1.00	0.05	0.05	0.10	0.01 miles
du=	**0.04**	**0.16**	**2.43**	**0.08**	**0.20**	**2.00**	**0.23** miles
Range r	0.25	0.25	0.25	0.25	0.25	0.25	0.25 miles
No in range	0	1	297	0	2	200	3 bases
% in range	**9.93**	**100**	**100**	**31.57**	**100**	**100**	**100**
% int hops	7.72	7.72	20.06	9.65	9.65	19.29	19.29 %
Ft=	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Pb=%	**3.09**	**3.86**	**100.00**	**3.86**	**7.54**	**100.00**	**19.08** %

Note: When "No. in range" = 0, Pb is for those devices in range.

Table 12A	**Near Far Ratio ref Metricom bases FH devices**		
	Phone indoor	Phone outdoor	Itron meter
Ptw=	27	27	-6 dBm
Ptu=	32	32	32 dBm
hw=	4	4	6 feet
hu=	25	25	25 feet
SNR=	15	15	10 dB
f=	10	0	0 dB
NFR(eff)=	**0.22**	**0.13**	**0.031**
dw=	0.01	0.02	0.01 miles
du=	**0.04**	**0.16**	**0.32** miles
Range r	0.25	0.25	0.25 miles
No in range	0	1	5
% in range	**9.93**	**100**	**100**
Ft=	0.4	0.4	0.4
Pb=%	**0.00**	**0.25**	**1.23** %

Note: When "No. in range" = 0, Pb is for those devicesin range.

Annex A

1 Propagation model

Throughout this paper, the 'Egli'[1] propagation formula is used. Namely:

$Lt = 85.9 + 20 \log F + 40 \log D - 20 \log hb - 20 \log hm$

F in MHz
D in kms
hm & hb in meters
hm < 10 m (mobile)

This formula can be re-written as:

$Lt = 114.7 + 20 \log F - 20 \log hb.hm + 40 \log D$

F in MHz
D in miles
hm & hb in feet

Assuming that F = 920 MHz, the received signal strength, Pr, is therefore:

$$Pr = Pt - 174 + 20 \log hb.hm - 40 \log D.$$

2 Desensitization and Range reduction of LMS mobile

From standard definitions, the thermal noise is -174dBm/Hz. For a 2Mbps direct sequence spread spectrum the main lobe bandwidth is 4 MHz. In 4 MHz bandwidth the thermal noise is -108dBm. Assuming a noise figure of 6 dB, the noise floor will be -102dBm.

Desensitization occurs when the 'noise' floor is raised by interference. In a direct sequence spread spectrum receiver, any un-correlated interfering signal becomes 'noise' by the action of de-correlation. Thus, the received power of an interfering signal can be considered as adding to the noise at the receiver front end. The effective noise at the receiver front end is thermal noise plus the noise figure. In the above example, this is -102dBm.

Therefore, an interfering signal received at a level of -92 dBm would effectively desensitize the receiver by 10 dB, and an interfering signal received at a level of -82 dBm would effectively desensitize the receiver by 20 dB

The propagation loss due to distance is "40 log D", thus a 10 dB desensitization is equivalent to reducing the range by a factor of $10^{10/40} = 1.78$.

A table of desensitization and range reduction factors is given in Table 1.

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[1] J.J.Egli, "Radio propagation above 40Mc over irregular terrain", Proc. IRE, vol. 45, no 10, pp. 1383-1391, Oct. 1957. This simple formula used for suburban propagation loss, gives results that agree very closely with the CCIR Okumura method and also with the Hata formulas (which are derived from the Okumura measurements). It is a well known formula used by radio engineers.

Table 1- Range reduction with desensitization					
Interference level, dBm	-102	-92	-82	-72	-62
Desensitization, dB	0	10	20	30	40
Range reduction factor	1	1.78	3.16	5.6	10

Thus, based on Table 1, an interfering signal 20 dB above the 'noise' will reduce the range by a factor of 3. This corresponds to a received level of -82dBm.

3 Penetration loss due to building

Work carried out on the radio coverage in buildings[2] has shown a floor attenuation factor, f, at 864 MHz, in a building as

$$5.5\text{dB} < f < 15\text{ dB} \quad \text{or } f = 10\text{ dB with a standard deviation of 5 dB.}$$

CCIR Report 567-2[3] gives a similar figure, for typical steel and concrete and stone office buildings, of 10dB with a standard deviation of 7.3 dB. Severe cases, with steel shell buildings resulted in 28.5 dB mean.

Therefore, for the purposes of this paper, a figure of 10dB is used for the penetration loss due to a building wall.

[2] Cordless Telecommunications in Europe, Wally Tuttlebee (Ed.), Springer-Verlag, Chapter 7, 'The Radio Channel", page 159.
[3] CCIR Report 567-2 "Methods and Statistics for Estimating Field Strength Values in the Land Mobile Services using the Frequency Range 30MHz to 1 GHz".(1978-1982), clause 5.3. "Building penetration loss". Measurements carried out in Louisville, Kentucky.

4. *Near-Far-Ratio, NFR.*

4.1. Interference to LMS Mobile

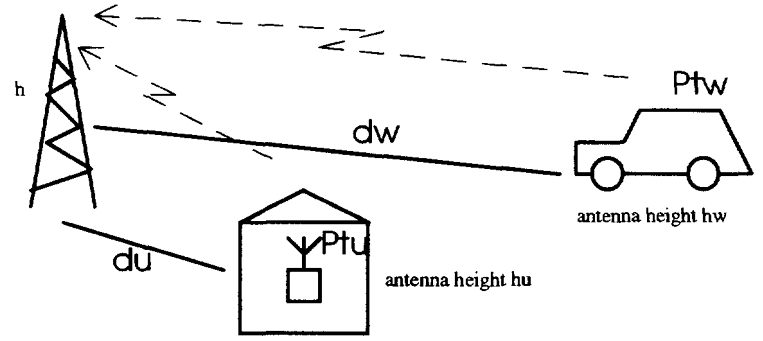

Figure 1 - Part 15 interfering with WB fixed site reception

Using 'Egli', the wanted received signal level is :

$$Prw = Ptw - 114.7 - 20 \log F + 20 \log hw.h - 40 \log dw$$

The unwanted received signal level is :

$$Pru = (Ptu - f) - 114.7 - 20 \log F + 20 \log hu.h - 40 \log du$$

The unwanted signal will be effectively reduced by the Jamming Margin (JM) of the wideband spread spectrum receiver, hence, for threshold of blocking:

$$Pru = Prw + JM$$

or $$(Ptu - f) + 20 \log hu.h - 40 \log du = Ptw + 20 \log hw.h - 40 \log dw + JM$$

Hence, $$40 \log dw/du = (Ptw + JM) - (Ptu - f) + 20 \log hw/hu \qquad (1)$$

where,

dw/du	is the NFR
Ptw	is the transmitted power of the LMS mobile
JM	is the jamming margin of the LMS system
Ptu	is the transmitted power of the Part 15 device
f	is the floor attenuation factor
hw	is the height of the LMS mobile
hu	is the height of the Part 15 device.

4.2. Interference to Part 15 from LMS fixed site

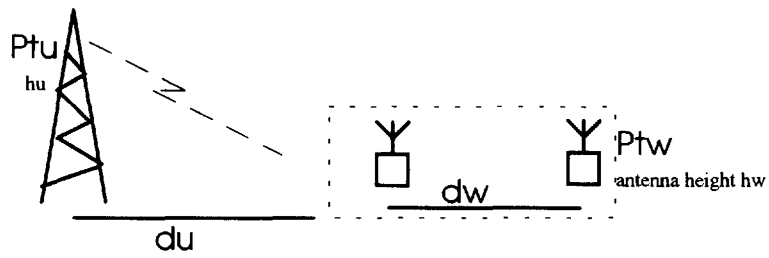

Figure 2 - LMS Fixed Site interfering with Part 15

Using 'Egli', the wanted received signal level is :

$$Prw = Ptw - 114.7 - 20 \log F + 20 \log hw.h - 40 \log dw$$

The unwanted received signal level is :

$$Pru = (Ptu - f) - 114.7 - 20 \log F + 20 \log hu.h - 40 \log du$$

The unwanted signal must be less than the wanted by the required signal to noise ratio, hence, for threshold of blocking:

$$Pru = Prw - SNR$$

or $$(Ptu - f) + 20 \log hu.h - 40 \log du = Ptw + 20 \log hw.h - 40 \log dw + JM$$

Hence, $$40 \log dw/du = (Ptw - SNR) - (Ptu - f) + 20 \log hw/hu \qquad (2)$$

where,

dw/du	is the NFR
Ptw	is the transmitted power of the LMS mobile
SNR	is the required signal to noise ratio of the Part 15 device
Ptu	is the transmitted power of the LMS site
f	is the floor attenuation factor
hw	is the height of the Part 15 device
hu	is the height of the LMS site.

If the occupied bandwidth of the unwanted signal, BWu, is greater than the bandwidth of the wanted signal, BWw, then (2) is modified to:

$$40 \log dw/du = (Ptw - SNR) - (Ptu - f) + 20 \log hw/hu - 10 \log BWw/BWu \qquad (2A)$$

5. Probability of Blocking of One Fixed Site

Consider a receiving site with a circular coverage area of unit radius, area π, as shown in Figure 2:

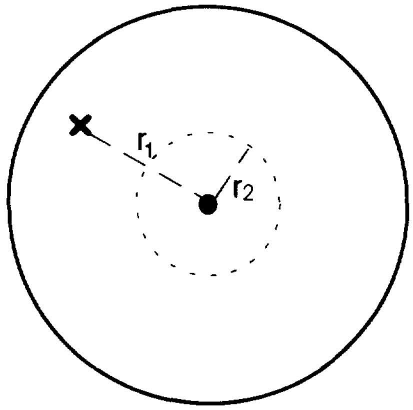

Figure 2 - Area of unit radius

For the wanted vehicle at distance r_1 from the site, then any interferer that is within a distance r_2 of the site is capable of blocking the transmissions if :

$$\frac{r_1}{r_2} \geq NFR \tag{2}$$

where NFR is the near-far-ratio.

Assuming an even distribution of vehicles and interferers over the area,

The proportion of units within the circle, radius r_2 is: $\frac{\pi (r_2)^2}{\pi} = r_2^2$

From (1)

$$(r_2)^2 = \left(\frac{r_1}{NFR}\right)^2 \tag{3}$$

This is the probability, P_{NFR} , that an unwanted transmission is inside the NFR and hence capable of blocking the wanted.

Probability that the wanted vehicle is close to r_1 is shown in Figure 3,

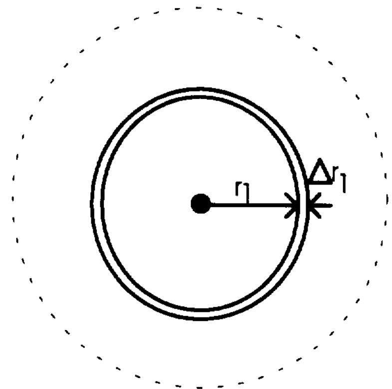

Figure 3 - Wanted vehicle position

Probability, P_{r1}, that the wanted vehicle is close to r_1 is:

$$P_{r1} = \frac{1}{\pi}[\pi(r_1 + \Delta r_1)^2 - \pi r_1^2] = 2r_1\Delta r_1 \qquad (4)$$

Hence, probability that wanted vehicle is at r_1 and unwanted transmission is within the near far ratio, is the product of (3) and (4):

$$P_{NFR}P_{r1} = \frac{2r_1\Delta r_1 r_1^2}{(NFR)^2} = \frac{2r_1^3}{(NFR)^2}\Delta r_1$$

Integrating wrt r_1 :

$$P_{bNFR} = P_{NFR}P_{r1} = \int_0^1 \frac{2r_1^3}{(NFR)^2}\partial r_1 = \frac{1}{2(NFR)^2} \qquad (5)$$

Let us now consider the probability that the unwanted radio is transmitting at the same time as the wanted.

Let Ft be the average fraction of time that the Part 15 device is transmitting.
Let there be N Part 15 devices in the unit area circle.

The chance of exactly n unwanted transmissions being present is given by the Poisson distribution:

$$P_{(n)} = \frac{(NF_t)^n}{n!}e^{-NF_t} \qquad (6)$$

If there are n unwanted transmissions, then the probability that they do not block the wanted is $(1 - P_{bNFR})^n$.

Thus, the probability that they do block, i.e. within the NFR, is:

$$1-(1-P_{bNFR})^n$$

The probability of blocking, P_b, is the product of the probability of there being n unwanted transmitters, $P_{(n)}$, and the probability that they are within the NFR.

Hence $$P_b=\sum_{n=0}^{N}(1-(1-P_{bNFR})^n)P_{(n)}$$

Expanding, $$P_b=\sum_{n=0}^{N}P_{(n)}-\sum_{n=0}^{N}(1-P_{bNFR})^n P_{(n)}$$

Now $\sum_{n=0}^{N}P_{(n)}=1$

Thus, $$P_b=1-\sum_{n=0}^{N}(1-P_{bNFR})^n P_{(n)} \qquad (7)$$

The probability that there are exactly n unwanted pulses is $P_{(n)}$, given by equation (6).

$$P_b=1-\sum_{n=0}^{N}\left(1-\frac{1}{2(NFR)^2}\right)^n\frac{(NF_t)^n}{n!}e^{-NF_t} \qquad (8)$$

Re-arranging and summing from 0 to ∞,

$$P_b=1-e^{-NF_t}\sum_{n=0}^{\infty}\left(1-\frac{1}{2(NFR)^2}\right)^n\frac{(NF_t)^n}{n!} \qquad (9)$$

$$P_b=1-e^{-NF_t}e^{NF_t\left(1-\frac{1}{2NFR^2}\right)}$$

$$P_b=1-e^{-\frac{NF_t}{2NFR^2}}, \qquad (10)$$

Solving for N $$N=-\frac{2.NFR^2.\log_e(1-P_b)}{F_t} \qquad (10A)$$

6. Frequency Hopping

In the case of frequency hopping radios, there is an added probability of the chance that the channel chosen by the wanted radio is already occupied.

Let there be M channels. The probability that a radio chooses a particular channel is $1/M$.

The probability that the radio is not on a particular channel is therefore $(1-1/M)$.

For n radios, the probability that they are not on a particular channels is therefore

$$\left(1-\frac{1}{M}\right)^n$$

Thus, the probability that the channels is occupied, P_{OC}, is:

$$P_{OC} = 1-\left(1-\frac{1}{M}\right)^n \tag{11}$$

In the case of frequency hopping radios, the probability of blocking is given by including the probability of the channel being occupied into equation (7).

Thus,

$$P_{bFH} = \sum_{n=0}^{N}\left(1-(1-P_{bNFR})^n\right)\left(1-\left(1-\frac{1}{M}\right)^n\right)P_{(n)} \tag{12}$$

$$P_{bFH} = \sum_{n=0}^{N}\left(1-\left(1-\frac{1}{2(NFR)^2}\right)^n\right)\left(1-\left(1-\frac{1}{M}\right)^n\right)\frac{(NF_t)^n}{n!}e^{-NF_t} \tag{13}$$

Re-arranging and summing from 0 to ∞,

$$P_{bFH} = e^{-NF_t}\sum_{n=0}^{\infty}\frac{(NF_t)^n}{n!}\left(1-\left(1-\frac{1}{2NFR^2}\right)^n-\left(1-\frac{1}{M}\right)^n+\left(1-\frac{1}{2NFR^2}\right)^n\left(1-\frac{1}{M}\right)^n\right)$$

$$P_{bFH} = e^{-NF_t}\left(e^{NF_t}-e^{NF_t\left(1-\frac{1}{2NFR^2}\right)}-e^{NF_t\left(1-\frac{1}{M}\right)}+e^{NF_t\left(1-\frac{1}{2NFR^2}\right)\left(1-\frac{1}{M}\right)}\right)$$

$$P_{bFH} = 1-e^{-\frac{NF_t}{2NFR^2}}-e^{-\frac{NF_t}{M}}+e^{-NF_t\left(\frac{1}{M}+\frac{1}{2NFR^2}-\frac{1}{2M.NFR^2}\right)} \tag{14}$$

If M >> NFR, then (14) reduces to

$$P_{bFH} = 1-e^{-\frac{NF_t}{M}} \tag{15}$$

From (15),

$$\frac{M}{N} = -\frac{F_t}{\log_e(1 - P_{bFH})} \tag{16}$$

In many cases the hopping is not synchronized and therefore each hop of one unit could coincide with two hops of another. This would change equation (11) to:

$$P_{OC} = 1 - \left(1 - \frac{2}{M}\right)^n \tag{11A}$$

This would change (15) to

$$P_{bFH} = 1 - e^{-\frac{2NF_t}{M}} \tag{15A}$$

7. Effect of Intermittent Transmissions by Part 15 Device

Equation (10) is the probability of blocking at an LMS site.

$$P_b = 1 - e^{-\frac{NF_t}{2NFR^2}}, \tag{10}$$

Thus,

$$1 - P_b = e^{-\frac{NF_t}{2NFR^2}} \tag{17}$$

$$NFR = \left[-\frac{NF_t}{2\log_e(1 - P_b)}\right]^{1/2} \tag{18}$$

If Pb, the probability of blocked site, and N, the number of unwanted devices, is kept constant, then the variation in NFR, the near-far-ratio, with Ft, the transmit duty factor, can be seen.

i.e.

$$\frac{NFR_1}{NFR_2} = \left(\frac{F_{t1}}{F_{t2}}\right)^{1/2} \tag{19}$$

Equation (1) can be re-written as $NFR^4 = JM.f\left(\frac{h_w}{h_u}\right)^2\left(\frac{P_{tw}}{P_{tu}}\right)$

or

$$NFR^4 = \frac{K}{P_{tu}} \tag{20}$$

where $K = JM.f.P_{tw}\left(\frac{h_w}{h_u}\right)^2$

K is a constant for any particular situation.

Substituting (20) into (19):

$$\frac{P_{tu1}}{P_{tu2}} = \left(\frac{F_{t2}}{F_{t1}}\right)^2 \qquad (21)$$

Equation (21) shows that by changing the transmit duty factor, the effective transmitted power, and hence the received signal level, is also varied. If $F_{t1} = 1$, and P_{tu1} is the actual transmitted power, then, from (21), the pulsed peak transmitted power, which has the same blocking effect as P_{tu1}, is :

$$P_{tu(pulsed)} = \frac{P_{tu}}{F_t^2}$$

or,

$$P_{tu(pulsed)} = P_{tu} - 20 \log F_t \qquad (22)$$

If $P_{tu(pulsed)} = P_{tu}$, i.e. the actual peak power is the same whether pulsed or continuous, then the effective received signal level is reduced.

Thus the equivalent interfering received signal is *Ptu - 20 log (1/Ft).*
or *Ptu + 20 log Ft* (23)

Annex B

Part 15 devices meeting Section 15.247.

1. Cordless Phones

1.1. Direct Sequence Spread Spectrum

The typical DSSS cordless phone, meeting Part 15.247, has the following characteristics:

- TDD
- 40-45% duty cycle
- 5-10 ms frames
- chipping rate is about 1 Mcps
- bit rate is in the order of 100 kbps
- about 20 frequency channels, spaced 1 MHz apart
- frequency agile in order to select an interference free channel.
- transmit power is 20-27dBm
- transmitted spectrum about 2 MHz wide.
- sensitivity -105 to -100 dBm
- CRC or known bit pattern (no FEC/interleaving, speech bits unprotected)

There is a 1 in 5 chance that the device chooses a frequency channel that coincides with one of the LMS sub-bands. The transmit duty factor, Ft, is 0.4, but because the frame time is only 5 -10 ms, i.e. less than the typical location burst time of an LMS system, this will not reduce the effective received interfering signal level. Because the device has multi-channels and will not select one with interference, the transmissions from an LMS system may cause it to avoid the LMS frequencies to some extent.

1.2. Frequency Hopping

The typical FH cordless phone, meeting Part 15.247, has the following characteristics:

- TDD
- 40-45% duty cycle
- 5-10 ms frames
- hopping rate less than 200 hops/sec
- bit rate is in the order of 100 kbps
- about 100 frequency channels
- dynamically replace channels to avoid interference
- transmit power is 20-27dBm
- transmitted spectrum about 200 kHz wide.
- sensitivity -105 to -100 dBm
- CRC or known bit pattern (no FEC/interleaving, speech bits unprotected)

Because the device hops over 100 frequency channels, the time spent within the LMS band will be low. Of the 100 channels it must be assumed that several are blocked. Assuming that there are, in practice about 75 channels in use, the device will be transmitting within the 4 MHz location burst main lobe, about 25% of the time. Thus a transmit duty factor, Ft, of 0.25 can be assumed.

2. Lower Rate Data Devices

2.1. Direct Sequence Spread Spectrum

Lower rate data devices using DSSS and meeting Part 15.247, typically have the following characteristics:

2.1.1. Wireless Data Modem

A wireless data modem is an outdoor device, typically mounted on buildings. The device usually is permanently transmitting. The following characteristics are from the "Airlink Multipoint Modem" manufactured by Cylink Corporation.

- chipping rate of 2.5 Mcps
- PN sequence of 32 bits
- bit rate up to 64 kbps
- 5.2 MHz bandwidth
- selectable center frequencies
- transmit power is 30 dBm
- transmitted spectrum about 200 kHz wide.
- sensitivity -95 dBm
- C/I of 0 dB

2.1.2. Cellnet System

The Cellnet meter reading system has the following characteristics:

- chipping rate is 1.2 Mcps
- bit rate is 19.2 kbps
- meter radio is fixed frequency channel.
- transmit power is, meter 23 dBm, base station 30 dBm
- bandwidth 2.5 MHz
- sensitivity -105 dBm
- transmit duty cycle in the order of 0.03%-0.007% meter, 1% to 3% base station
- transmit burst 20 - 30 msecs.
- ARQ
- base stations spaced on 0.25 mile grid
- base stations are pole mounted 18 to 25 feet high
- expected density of 1,000-10,000 devices/sq. mile
- private circuit or leased backbone

Assuming that there are 10 channels, there is a 1 in 5 chance that a meter is in an LMS band.

2.2. Frequency Hopping

2.2.1. Metricom "Ricochet" Network

The Mobicom "Ricochet" network has the following characteristics:

- IF bandwidth 30 kHz
- sensitivity -100 dBm
- HDLC packet with 32 bit CRC and ARQ.
- hopping rate 40 hops/sec (25 ms period)
- bit rate is in the order of 76.920 kbps
- 162 frequency channels
- bandwidth 160 kHz
- dynamically replace channels to avoid interference
- transmit power base 32 dBm ERP, portable 30dBm ERP
- listen before talk and/or channel quality.
- transmit duty cycle 40% peak, 5% typical.

- distance between base stations, 0.25 to 1 mile
- pole-mounted base stations
- concentrator stations spaced about 8 miles on building tops
- concentrator stations consist of 4 to 8 directional radios.
- average of 3 base stations used to deliver messages to concentrator.

The number of channels within the LMS band is about 35. The transmit duty factor, Ft, therefore will be 0.086 (35/162 x 0.4) peak and 0.01 typically.

2.2.2. Itron Meter Reading System

Although the Itron system only transmits in the 910 to 920 MHz band, and therefore does not co-exist in the proposed LMS bands, it is useful to consider the characteristics.

- 16 kbps data rate
- 6 ms message length
- 8 transmissions per message
- each message transmitted on different frequency with 100ms gap between hops
- transmit power -6 dBm
- 200 kHz IF bandwidth
- 48 channels, spaced 200 kHz
- sensitivity -115 dBm for 50% message error rate
- 50% of meters indoor, 50% outdoor

- device only transmits on reception of 'wake-up' signal (on licensed frequency)
- transmits again if 'wake-up' signal still present after 10 seconds

When in operation , the meter transmits a total of 48ms in a 10 second period. Assuming the system was operating over 20 MHz, the possibility of being in an LMS band would be 30%. Hence the worst case value for Ft is 0.0014.

Annex C

Part 15 Devices meeting Section 15.249.

Devices meeting section 15.249 are limited to a transmission power equivalent to 0.75mW ERP measured in 100kHz bandwidth. Particular devices which have caused interference problems to LMS systems are video links, indoor and outdoor, and security anti-theft devices. A major factor is that these devices transmit continuously.

Annex D

LMS Systems

Basic Parameters

The basic parameters of the LMS systems are:

	MobileVision	Teletrac	Pinpoint	Quiktrak	Uniplex
Mobile TX power	2/10W	0.5/10 W	40W	5/10W	20W
Site Antenna Gain	9dBi	9dBi	12dBi		
Site spacing	8mls		7mls	20mls	10mls
Spread Spectrum					
Burst length	10/55ms	11/23ms	0.3/7ms	278ms	7-21ms
Chipping rate	2Mcps	1.5Mcps	5.768Mcps	1Mcps	4Mcps
C/I (site)	-15dB	-15/23dB	-10dB		
C/I (mobile)			0dB		-10dB
Sensitivity (site)	-118dBm	-118dBm	-105dBm	-120dBm	-110dBm
Sensitivity (site) designed	-108dBm	-108dBm	-85dBm	-110dBm	-95dBm
Sensitivity (mobile)			-100dBm		
Narrowband					
Mobile RX NB sensitivity	-115dBm	-115dBm		-90dBm	
Site RX sensitivity	-115dBm	-112dBm			
Bandwidth	12.5kHz	25kHz		25kHz	
Data Rate	8kbps	2400bps			
Modulation	FSK	FSK			
Forward links					
TX power	300W	300W	500W	300W	300W
Frequency Band	250kHz	250kHz	8MHz	250kHz	8MHz
Duty Cycle	100%	100%	1-10%	100%	0.4%

REED SMITH SHAW & McCLAY

1200 18TH STREET, N.W.
WASHINGTON, D.C. 20036-2506

202-457-6100

FACSIMILE
202-457-6113
TELEX NO. 64711

WRITER'S DIRECT DIAL NUMBER

PITTSBURGH, PA
PHILADELPHIA, PA
HARRISBURG, PA
McLEAN, VA
PRINCETON, NJ

(202) 457-8646

December 13, 1994

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, N.W., Room 222
Washington, D.C. 20554

Re: Ex Parte Contact
PR Docket No. 93-61

Dear Mr. Caton:

Pursuant to Section 1.1206 of the Commission's Rules, notice is hereby given of an ex parte communication regarding the above-referenced proceeding. The instant notice is being submitted in duplicate.

On December 13, 1994, the undersigned and Donald R. Gray and Graham Smith, CEO and Director/Systems Research, respectively, of MobileVision, L.P., met with Bruce A. Franca, Deputy Chief Engineer, and Alan Stillwell, Economics Advisor, Office of Engineering & Technology, concerning various of the issues in this proceeding. A copy of materials that were delivered at the meeting are attached.

Please associate this notice and the attached materials with the record in this proceeding.

Sincerely,

REED SMITH SHAW & McCLAY

John J. McDonnell

cc: Bruce A. Franca (w/o encl.)
Alan Stillwell (w/o encl.)
Rosalind K. Allen (w/encl.)
F. Ronald Netro (w/encl.)
Martin D. Liebman (w/encl.)
John J. Borkowski (w/encl.)
Thomas Dombrowsky (w/encl.)